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Implications of variation in local perception of degradation and restoration processes for implementing land degradation neutrality

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ABSTRACT

The concept of land degradation neutrality (LDN) is a new approach receiving considerable interest because of its potential to address land degradation. Implementing LDN presents a number of challenges primarily concerned with the choice of scales of operation at which to apply it and then, monitoring and assessing degradation status and trends at these scales. In the absence of studies that apply the concept to local scales and engage local stakeholders, our study was undertaken in the Gilgel-Abay watershed of northwest Ethiopia using sites that equate to a local landscape scale (10–1000 km^2) at which decisions about land use are made. Combining participatory mapping, farmer interviews and a field survey of soil erosion prevalence, our objectives were to: (i) understand local perceptions of land degradation and restoration activities; (ii) assess their implications for LDN, and (iii) explore the utility of engaging local land users in the assessment of land degradation and restoration activities. Our findings demonstrate that engaging land users can provide a comprehensive overview of land degradation and restoration activities at local scales; that land users may not share the same priorities, in terms of where, when and how to address degradation, as one another, or with other actors involved in restoration initiatives, which implies a need for negotiation; and that the impacts of restoration activities are likely to be socially differentiated. This makes it important to understand how livelihoods interact with different restoration interventions and to take measures to ensure that striving for LDN does not disadvantage the most vulnerable people. Based on these findings, we propose three guiding strategies for implementing LDN at local scales: negotiate priorities and incentivize action; match options to context; and, co-produce knowledge and indicators.

1. Introduction

Land degradation, defined as the loss or persistent decline in the capability of land to provide ecosystem services (ES), presents a major threat to global food security, economic development and the well-being of billions of people around the world (Lal et al., 2012). While the global extent and location of degraded lands is disputed, estimates indicate that up to 25% of the Earth's land area may be severely degraded (FAO, 2011) and that, despite global efforts to halt land degradation, the area affected continues to increase (Bai et al., 2008; Lal, 2012). The concept of land degradation neutrality (LDN), "a state whereby the amount and quality of

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land resources necessary to support ecosystem functions and services and enhance food security remain stable or increase within specified temporal and spatial scales and ecosystems" (UNCCD, 2016), is a new approach receiving considerable interest for its potential to address land degradation. As a result, striving for a land degradation neutral world has been made a global objective under the UN Sustainable Development Goal 15.3: "By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world".

Recent assessments of implementing LDN highlight a number of challenges, primarily concerned with the monitoring and assessment of degradation and the scale at which to apply the LDN concept (Akhtar-Schuster et al., 2017; Chasek et al., 2015; Grainger, 2015; Stavi and Lal, 2015). In order to achieve LDN, it is proposed that measures must be taken to avoid and reduce the degradation of non-degraded land and any anticipated losses of productive land offset through the restoration[1] of areas that are already degraded. To support this, effective monitoring mechanisms will be needed to: determine the degradation status of land, distinguishing degraded from non-degraded land and land under the process of degradation; assess the effectiveness of interventions; and inform priority setting.

Actions will also need to be applied across a range of scales (Chasek et al., 2015; Grainger, 2015; Welton et al., 2014). Land use change is largely driven by the cumulative effect of individual management decisions made at the field or farm level (Pagella and Sinclair, 2014). Achieving LDN at the national scale is, therefore, an aggregate of what happens locally. Yet, most of the current discourse on LDN focuses on its implementation and monitoring at the national scale, rather than the local, since LDN commitments and compliance are reported and assessed nationally (Gnacadja and Wiese, 2016; López Santos, 2016; Safriel, 2017; Salvati et al., 2013; Willemen et al., 2017).

The United Nations Convention to Combat Desertification (UNCCD) Science Policy Interface recently published a "scientific conceptual framework", that advocates the use of three indicators for measuring progress towards LDN: (i) trends in land cover change, (ii) trends in land productivity, and (iii) trends in soil organic carbon stocks (Cowie et al., 2018; Orr et al., 2017). While these indicators are designed to provide a synoptic view of where actions are contributing or detracting from LDN within nations, monitoring is needed at scales fine enough to capture the impacts of LDN activities at the local scale –defined by Pagella and Sinclair (2014) as "the scale at which ground level decisions about change in land use are made" and encompasses "fields and farms up to an immediate landscape scale of 10–1000 km^2 at which many ES initially manifest". Cowie et al. (2018) and Orr et al. (2017) also stress the need to implement LDN at the scale at which land use decisions are made and that complementary indicators will be needed to monitor locally specific issues and to develop locally appropriate LDN strategies.

As discussed by Pagella and Sinclair (2014), when it comes to the management of ES, there is often disconnect between international and national policies and their implementation. Although the need to work at local scales when managing ES is well recognised, assessment tools that work at the appropriate scales and resolutions to do so are limited. Not only does this constrain policy makers in assessing the value of different land management options, it limits the ability of land users to comprehend the impacts of their decisions on ecosystem service provision, and could potentially hamper the uptake of LDN activities.

Pagella and Sinclair (2014) also note that ES mapping approaches rarely incorporate the knowledge or perspectives of stakeholders, especially that of local land users, resulting in a lack of information regarding their preferences and priorities. Within the LDN literature, we are aware of only one study that incorporates stakeholder perspectives in the identification of priority areas for LDN investment (Willemen et al., 2017), and since its focus is on national level priorities, only national level stakeholders were consulted. Willemen et al. (2017) acknowledge that while their mapping outputs may be useful for targeting national LDN investment, their resolution and accuracy may be insufficient for local level decision-making and that priorities identified by national level stakeholders may clash with those held by local actors.

A failure to understand local priorities and involve land users in the monitoring and assessment of LDN is likely to constrain the development and adoption of locally appropriate strategies and misses opportunities for negotiating land management objectives and ground-truthing data. Local knowledge, that is, knowledge held by people in a particular locality derived through observation and experience (Sinclair and Walker, 1999), has often been found to be largely complementary to global scientific knowledge on soils and environmental change (Bart, 2006; Berkes, 2009; Joshi et al., 2004). It is, therefore, a reasonable expectation that involving land users in the assessment of degradation may be a valuable addition to the current UNCCD LDN framework. The co-production of knowledge using participatory approaches, such as participatory mapping (Reed and Dougill, 2002), modeling (Vanclay et al., 2006) and indicator development (Reed et al., 2008), can also increase the local legitimacy of monitoring outputs and empower local communities to take action against degradation. Acquiring local knowledge and the use of participatory approaches necessarily involves engaging local stakeholders at the scale of their operation and perception, embracing a finer scale application of the LDN concept than has been previously envisaged.

In response to the absence of studies that apply the LDN concept at local scales and involve local land users in the assessment of degradation, our present research was undertaken using sites that equate to a local landscape scale (10 –1000 km^2), located in the Gilgel-Abay watershed of northwest Ethiopia. This is an area suffering from extensive soil erosion and where local communities have recently acted to restore degraded lands. Combining participatory mapping, farmer interviews and field surveys of soil erosion prevalence, our objectives were to: (i) understand local perceptions of land degradation and restoration activities; (ii) assess their

[1] *Restoration: [activities that] reverse degradation processes and increase ecosystem service provision. Note this definition is broader than that provided by the UNCCD Conceptual Framework for LDN, which makes a distinction between activities that seek to re-establish "pre-existing biotic integrity, in terms of species composition and community structure" (referred to as restoration) and those which "aim to reinstate ecosystem functionality with a focus on provision of goods and services" (referred to as rehabilitation)* (Cowie et al., 2018).

Table 1
Site information provided by local agricultural offices.

	Lalibela	East Zelsea
Total area (km^2)	58	16
Total population	10,457	1964
Number of households	1683	410
Mean farm size (ha)	1.5	1

implications for achieving LDN, and (iii) explore the utility of engaging local land users in the assessment of land degradation and restoration activities. Lessons from this research, considered in the light of farmer participatory research more generally, were expected to inform the development of strategies to implement LDN at local scales, complementing the current UNCCD LDN framework.

2. Materials and methods

2.1. Study area and site selection

Our study focuses on two *kebeles*, the smallest administrative unit of Ethiopia, located within the Gilgel-Abay watershed of the Amhara National Regional State of Ethiopia (Table 1). We chose to base our local landscape scale on these administrative boundaries because a number of important land use planning decisions are made at this level (e.g., priority areas for restoration efforts) and most agricultural services and support are administered at this level. The use of *kebele* as a unit of observation also provides a clear and delineated area, familiar to most land users.

The Gilgel-Abay watershed covers 4027 km^2 and is one of three major watersheds which form the Lake Tana catchment (Zimale et al., 2016). Within the watershed, elevation ranges from 1800 to 3500 m above sea level, and the topography transitions from rugged in the south to a plateau with gentle slopes in the north (Uhlenbrook et al., 2010). The area is dominated by clay and clayey loam soils and has one main rainy season between June and September (Uhlenbrook et al., 2010).

The area has experienced extensive land degradation in the form of soil erosion and soil nutrient depletion, largely attributed to the over-exploitation of communal resources and conversion of marginal land (BOA, 2013). Over the past decade, local communities have invested heavily in restoration efforts supported through annual government-led campaigns (BOA, 2013, 2007). These campaigns have included establishment of soil and water conservation (SWC) structures, such as soil bunds, cut-off drains and check dams, as well as exclosures, which are a restorative land use intervention that promotes the regeneration of natural forest vegetation through the exclusion of livestock and agriculture.

The selected *kebeles*, Lalibela (58 km^2) and East Zelsea (16 km^2), are areas with current government-led efforts to reduce and reverse degradation (SWC structures and exclosures) and chosen to represent areas of high and low erosion prevalence (Lalibela and East Zelsea, respectively) as determined by Vågen (2016) (Fig. 1).

While both SWC structures and exclosures can be used to reduce and reverse degradation, within our study area SWC structures tended to be applied to land that showed declining productivity but were still heavily utilised. Exclosures on the other hand tended to be established on severely degraded land (i.e., very low productivity and shallow, stony soils). In this way, SWC structures can be seen as interventions used to reduce the rate of degradation and exclosures as an intervention used to reverse severe land degradation.

Both sites are intensely utilised with nearly all land being used for cultivation, grazing or woodlots, and any remnant forest cover largely restricted to areas surrounding churches. Farming is predominantly mixed crop and livestock for subsistence and income, with small farm sizes and many people, especially those of younger age, not having access to their own land. Open grazing of livestock is practiced all year round on the majority of communal lands and the main crops grown are maize, teff and millet.

Both *kebeles* have implemented areas of SWC structures and exclosures within the past five years: East Zelsea having an 80 ha exclosure established in 2012 and Lalibela a 7 ha exclosure established in 2011. Both exclosures are protected by local by-laws and managed through a “cut-and-carry” system, where grasses are harvested and taken to stall fed animals. In East Zelsea the whole community is allowed to harvest grass from the exclosure. In Lalibela usufruct rights over the exclosure have been assigned to a group of landless households who use it for income generating activities such as livestock fattening, beekeeping and selling fodder to other members of the community.

2.2. Data collection

Our study integrates participatory mapping, remote sensing, semi-structured interviews and a field survey of soil erosion prevalence. We use participatory mapping and semi-structured interviews, as they are well-established and effective methods for capturing the perspectives of local land users (Chambers, 2008; Desai and Potter, 2006). Our main aim was to understand local perceptions about degradation and their implications for LDN, rather than to contribute new measurements of degradation processes, therefore, we conducted a rapid field survey of soil erosion prevalence in order to triangulate farmers’ perceptions of degradation. Two transect walks and six semi-structured interviews with local development agents were also conducted (Geilfus, 2008), providing

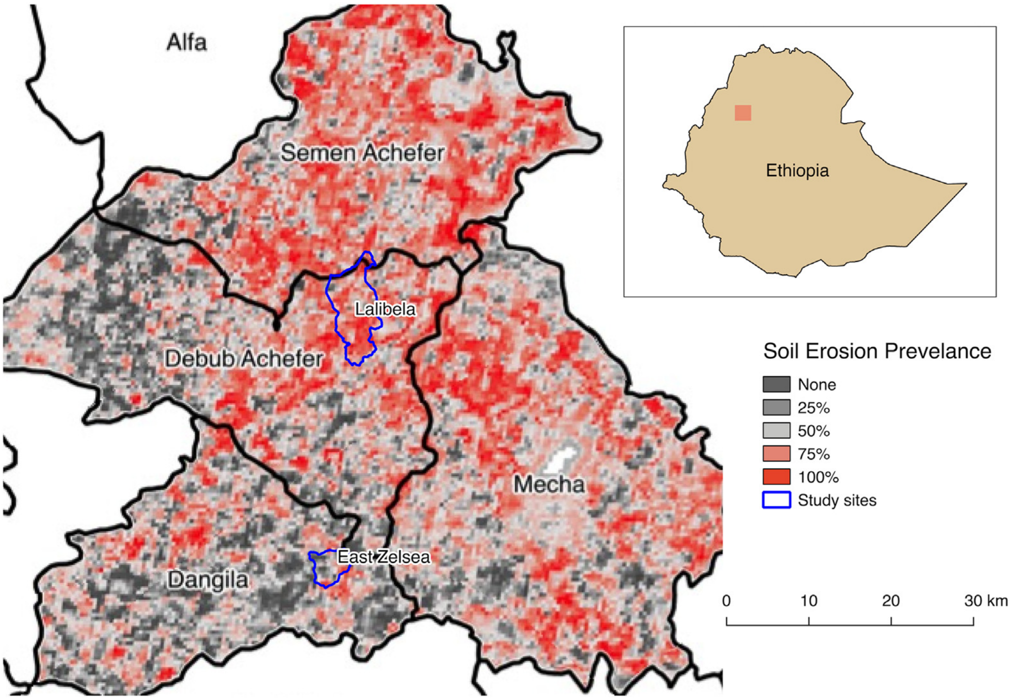

Fig. 1. Erosion prevalence map used for site selection, produced by ICRAF GeoScience Lab using MODIS Imagery (Vågen, 2016), and the location of study sites: Lalibela and East Zelsea.

an initial overview of the socio-economic and environmental context within the study area and general information on local livelihood strategies, land use and agricultural practices. All fieldwork activities were conducted in June and July 2016.

2.2.1. Participatory mapping and farmer interviews

Qualitative data on farmers' perceptions of degradation and restoration activities were collected from 107 participating farmers (80 men and 27 women), through six participatory mapping groups involving 55 people, 34 individual semi-structured interviews and 18 open-ended field-based interviews (each participant being involved in only one method) (Table 2). Local development agents were asked to purposively select participants of different ages, gender and levels of wealth from dispersed areas of each *kebele*, so as to gain the perspectives of different social groups and minimise spatial bias.

Semi-structured interviews and mapping groups covered similar topics, including the type, causes and location of degradation, trends in land use over the past 30 years, and the perceived challenges and benefits of SWC structures and exclosures. Farmers were also asked to identify areas of their kebele that they considered: (i) Degraded: have experienced severe degradation and are no longer considered productive, (ii) Degrading: will become severely degraded in the next 5–10 years, (iii) Under restoration: where exclosures and SWC structures have been applied, and iv) priorities for future restoration efforts. Given the subjective nature of what is considered degraded (Hobbs, 2016) and our interest in land users perceptions, we purposely chose to provide participants with broad definitions for degraded and degrading land, allowing them to articulate their own interpretations.

Sites mentioned during interviews were later located by local development agents using local toponyms and satellite images of each *kebele* (A1 size at 1:18,000 scale), while mapping participants were asked to draw such areas onto these images using transparent plastic overlays.

Table 2
Number and gender of participants involved in participatory mapping and individual interviews. Each participant was involved in only one method.

	Lalibela		East Zelsea	
	Men	Women	Men	Women
Participatory mapping				
Held as gender disaggregated groups	10	7	8	9
Held as a mixed-gender group	5	4	6	6
Interviews				
Semi-structured	14	–	19	1
Field-based	12	–	6	–
Total	41	11	39	16

Designed to provide rapid assessment of farmer perceptions, semi-structured interviews lasted 20–30 min and mapping sessions 1–2 h. While efforts were made to disaggregate mapping groups by gender, time constraints and difficulties in recruiting female participants meant that two out of the six groups contained both men and women, while the other four groups contained either only men or only women. In addition to the semi-structured interviews, open-ended field-based interviews were also conducted with farmers encountered while undertaking the field survey.

Textual data from notes taken during interviews and mapping sessions were then coded thematically using the software QDA Miner 4, and dominant topics raised by farmers compared across study sites, mapping groups and individual cases (Hennink et al., 2011). Aggregated by site and gender, mapping outputs were digitised using Quantum GIS in order to clearly display and compare spatial information on degradation and restoration.

2.2.2. Field survey

Field survey sites were purposively selected from areas mentioned by interview and mapping participants to represent the three main land use types within the study area: cropland, communal grazing and exclosure; and areas of both degradation and restoration (13 and 14 survey sites in East Zelsea and Lalibela, respectively). Soil erosion was then assessed using methods adapted from the Land Degradation Surveillance Framework (LDSF) Field Guide (Vågen et al., 2013), whereby three sampling points were located randomly within each survey site and the presence/absence and dominant type of soil erosion (sheet, rill or gully) recorded for four 100 m^2 circular subplots using an “LDSF radial arm” configuration (see Vågen et al., 2013). Observations were made in a total of 332 subplots: 168 and 164 in Lalibela and East Zelsea, respectively.

We chose to assess soil erosion because it is the dominant form of land degradation found within the study area (BOA, 2013); easily visible, lending itself to rapid assessment with minimal equipment; and was identified during interviews and participatory mapping as one of the main indicators of degradation used by farmers. Given the nominal nature of the survey data, we applied non-parametric statistical analyses using the statistical software R. Results from the field survey are referred to throughout the results and discussion in order to inform and further explore findings regarding farmers’ perceptions.

3. Results

3.1. Farmers’ perceptions of degradation

In both study sites, the main forms of degradation cited by farmers were visible soil erosion and declining agricultural productivity. On cropland, farmers used a range of indicators to assess degradation including the depth and stoniness of the soil, changes in yield and crop health, gully expansion and impacts on land management such as the ease of ploughing and changes in fertilizer requirement. For the assessment of grazing land, indicators included changes in grass and livestock productivity, gully expansion, herbaceous cover, and the prevalence of unpalatable plants for livestock.

The majority of sites farmers in East Zelsea considered degraded or degrading were located on cultivated land, while the majority of sites farmers in Lalibela considered degraded or degrading were found on grazing land (see Figs. 2 and 3). This is reflected in the field survey results where erosion was present in 83% of observations taken on cultivated land within East Zelsea and only 44% of observations taken in Lalibela (Table 3). In contrast, 85% of observations made on grazing land in Lalibela had erosion present compared to only 52% of observations taken in East Zelsea.

This may be partially explained by the characteristics of grazing areas found in East Zelsea, which are generally flat, low lying areas receiving large amounts of sediment from the upper catchment. Large gullies were observed to be the dominant form of soil erosion in these areas, cutting through otherwise productive grassland. In Lalibela, on the other hand, grazing land was often located on hillsides and the dominant form of degradation widespread sheet erosion. These observations are reflected within the field survey results that show a significant difference in soil erosion type and prevalence between land uses types and that 57% of observations made on grazing land in Lalibela were affected by sheet erosion compared to only 2% in East Zelsea (Table 3 and 4). In East Zelsea, 41% of observations made on grazing land were affected by gully erosion compared to only 21% in Lalibela.

Farmers in both sites recognised that while inherent characteristics such as soil type, topography and heavy rainfall made their local areas susceptible to erosion by water, human actions and management practices over the past 30 years had also led to increased run-off and soil erosion (Table 5). Our discussions with farmers suggest that population growth and a shortage of agricultural land have led to hillsides being cleared of vegetation for cultivation. As a result, run-off from the upper slopes has increased and was perceived by farmers to be a primary cause of soil erosion. One farmer described this link between reduced vegetation cover and soil erosion as “like putting butter on a bald person’s head - the butter slips off. If you have hair, it will stay”. Similarly, farmers reported that high stocking densities on communal grazing land, presumably because of high dependency on and valuation of livestock, had resulted in reduced herbaceous cover and increased soil erosion.

Farmers also considered the practice of *fesses*, traditional drainage ditches created by individual farmers using a plough, to be a key driver of soil erosion and conflict amongst neighbouring farmers. Used on sloping land where SWC structures have not yet been constructed, these ditches intercept and divert run-off away from cropland and downslope onto neighbouring cropland, grazing land and nearby gullies. When asked to predict where within their *kebele* future gully erosion might occur, mapping participants in East Zelsea reported the use of *fesses* to be a key determinant and that grazing land surrounded by sloping cropland was particularly vulnerable. In response to farmer perceptions, we included the presence/absence of *fesses* within our field survey.

Based on observations from both *kebeles*, our field survey results showed erosion to be present in 76% of observations taken on cropland with *fesses* but only 25% of those on cropland without (Table 3). This corroborates the farmers’ perception that the use of

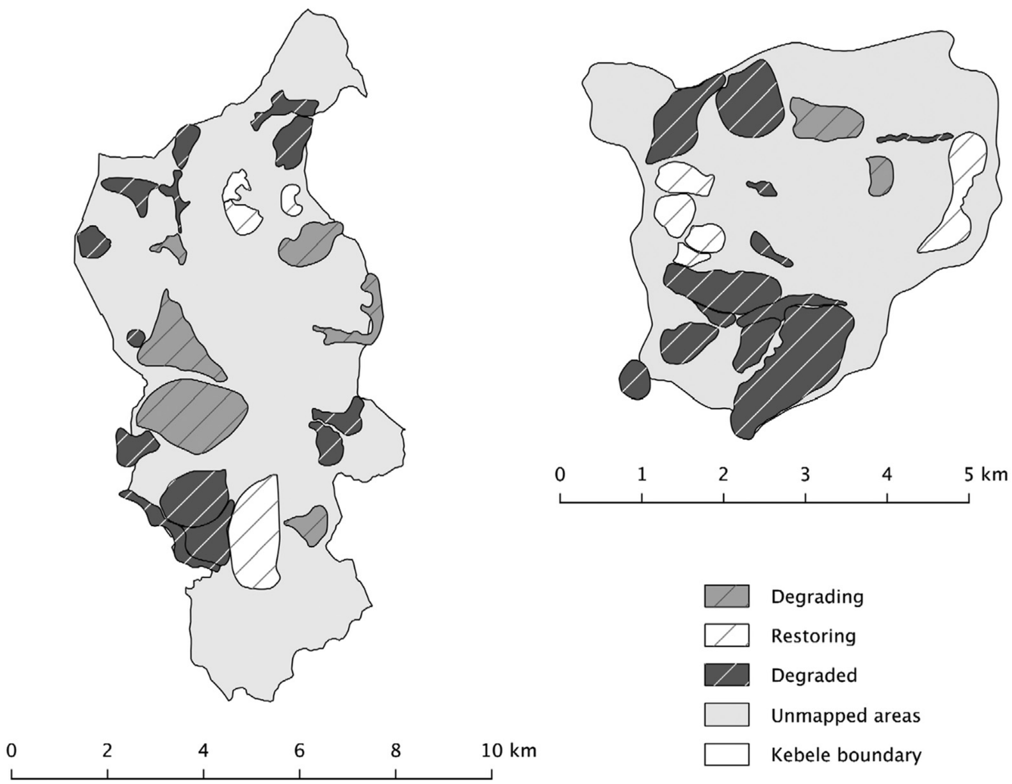

Fig. 2. The perceived degradation status for areas discussed by farmers interviewed in Lalibela (left) and East Zelsea (right). Due to time limitations, it was not possible to discuss all areas within each kebele. Unmapped areas, represented by the light grey spaces within mapping outputs, were therefore excluded from further analysis.

fesses contributes to soil erosion. However, we chose not to explore this correlation statistically because of the low representation of cropland sites without *fesses*, particularly in East Zelsea (n = 4). Care should be taken when interpreting our survey results at the *kebele* level. Potential explanations for the low number of observations taken on cropland without *fesses* include their widespread use across the study area and the majority of survey sites having been selected based on areas farmers considered to be degraded or degrading, making cropland with *fesses* more likely to be chosen.

The widespread use of *fesses* despite their negative impact may be explained by farmers' reliance on local extension services for guidance on the design of SWC structures and the annual work campaigns for labour to construct them. Farmers located in areas that had not yet been targeted by extension efforts and work campaigns were thought to rely on fesses for run-off management because they lacked the labour and knowledge needed to establish SWC structures.

3.2. Variation in farmers' perceptions of degradation

While farmers' perceptions of degradation were generally found to be similar, a number of key differences regarding gender and perceived degradation status were noted. Participatory mapping outputs for East Zelsea revealed substantial differences in the spatial perceptions of degradation between male and female groups (Fig. 4). Discussion within all female groups focused on the degradation of riverbanks and cropland near to homesteads, while the all male groups focused on communal grazing land and areas of irrigation. In addition to their role in field agriculture, women were responsible for the production of horticultural crops around the homestead and collecting water and fuelwood. This suggests that perceptions vary with respect to gender roles; consistent with men and women being most likely to observe degradation at the spatial locations they spend most time and effort.

Based on farmers qualitative assessment of degradation (Table 6 and Fig. 2), a larger percentage of East Zelsea is considered "degraded" compared to Lalibela, even when both "degraded" and "degrading" categories are considered together. This contradicts the erosion map used for site selection (Fig. 1) which clearly shows Lalibela to be more degraded than East Zelsea. Potential reasons for this discrepancy include the large areas of each *kebele* left unmapped by participants and for which we do not know their evaluation of the degradation status, and the fact that farmers' perceptions of severe degradation may differ between the two sites. Farmers also used a range of indicators to assess degradation not just soil erosion prevalence, the metric used in Fig. 1.

In terms of degradation dynamics, farmers in Lalibela perceived a larger percentage of their *kebele* to be degrading compared to farmers in East Zelsea, while farmers interviewed in East Zelsea perceived a larger percentage of their *kebele* to be under restoration (Table 6). Given that the area of land under restoration outweighs that of degradation, East Zelsea is perceived to be in net restoration

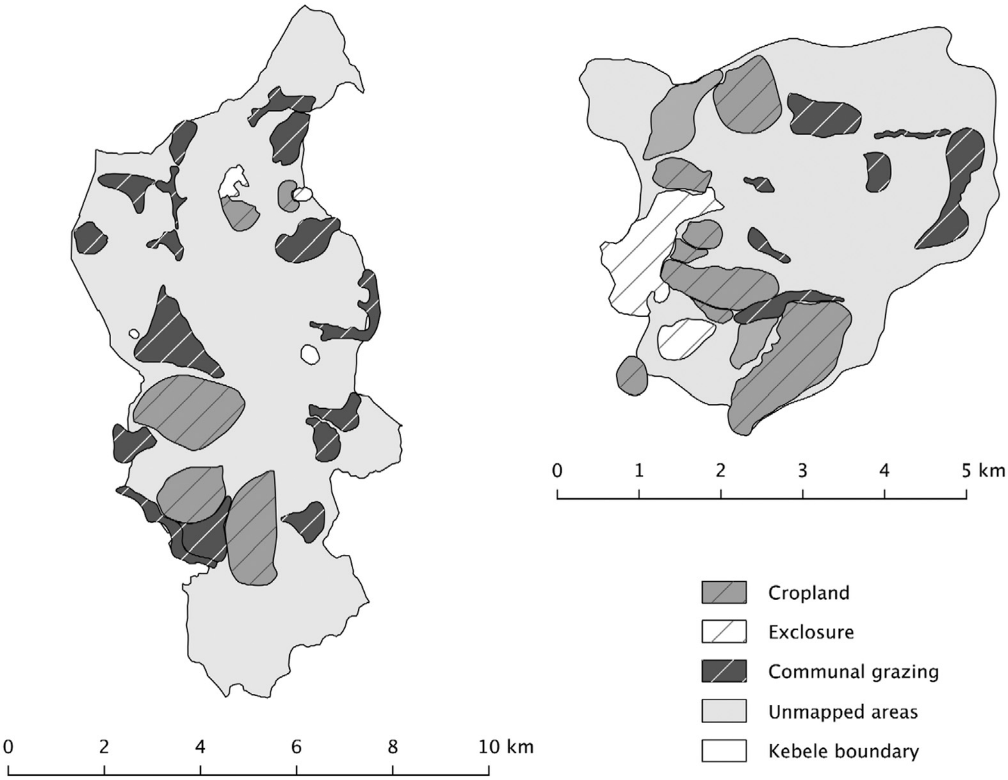

Fig. 3. Primary land uses for sites discussed by farmers interviewed in Lalibela (left) and East Zelsea (right).

Table 3
Summary of field survey results.

	Number of observations			% of observations with erosion		
	East Zelsea	Lalibela	Total	East Zelsea	Lalibela	Average
Land use type						
All land uses	164	168	332	71.34	70.24	70.78
Grazing	44	108	152	52.27	85.19	75.66
Cropland	108	48	156	83.33	43.75	71.15
Exclosure	12	12	24	33.33	41.67	37.50
Cropland management						
With SWC	60	44	104	76.67	38.64	60.58
Without SWC	48	4	52	91.67	100.00	92.31
With *fesses*[a]	104	36	140	82.69	58.33	76.43
Without *fesses*[a]	4	12	16	100.00	0.00	25.00
	Number of observations			% of observations with erosion by erosion type and land use		
Erosion type (for grazing)						
None	21	16	37	47.73	14.81	24.34
Sheet	1	62	63	2.27	57.41	41.45
Rill	4	7	11	9.09	6.48	7.24
Gully	18	23	41	40.91	21.30	26.97
Erosion type (for cropland)						
None	18	27	45	16.67	56.25	28.85
Sheet	51	14	65	47.22	29.17	41.67
Rill	27	1	28	25.00	2.08	17.95
Gully	12	6	18	11.11	12.50	11.54
Erosion type (for exclosure)						
None	8	7	15	66.67	58.33	62.50
Sheet	2	4	6	16.67	33.33	25.00
Rill	0	0	0	0.00	0.00	0.00
Gully	2	1	3	16.67	8.33	12.50

[a] Traditional drainage ditches created using oxen and plough that intercept and divert run-off away from farmers' fields.

Table 4
Associations between erosion type and prevalence with land use and the presence of SWC structures.

	Chi-squared	P-value
Variables		
Presence of SWC structures – erosion prevalence	15.50	**
Land use – erosion prevalence	14.61	*
Land use[a] – erosion type	16.34	**
Land use[a] – sheet erosion	0.19	ns
Land use[a] – rill erosion	8.64	*
Land use[a] – gully erosion	10.76	*

ns, not significant at $P > 0{\cdot}05$.
* Significant at $P \le 0.01$.
** Significant at $P \le 0{\cdot}001$.
[a] Exclosure excluded from analysis due to small sample size or inadequate representation of certain erosion types.

Table 5
Causes of land degradation on grazing land and cultivated land cited by study participants.

Causes of degradation cited	On grazing land	On cropland
Human actions		
Over grazing	X	
Road construction	X	
Expansion of cultivated land	X	
Roads used by livestock	X	X
Use of traditional drainage ditches (*fesses*)	X	X
Deforestation and removal of woody cover	X	X
No SWC structures	X	X
Cultivation on sloping land		X
Continuous cultivation due to land shortage		X
Use of irrigation canals		X
Ploughing down slope and of grass boundaries		X
Open grazing		X
Abiotic factors		
Topography/slope	X	
Deposition of sand and gravel	X	
High rainfall and run-off	X	X
Susceptible soils (Vertisols)	X	X
Flooding of river		X

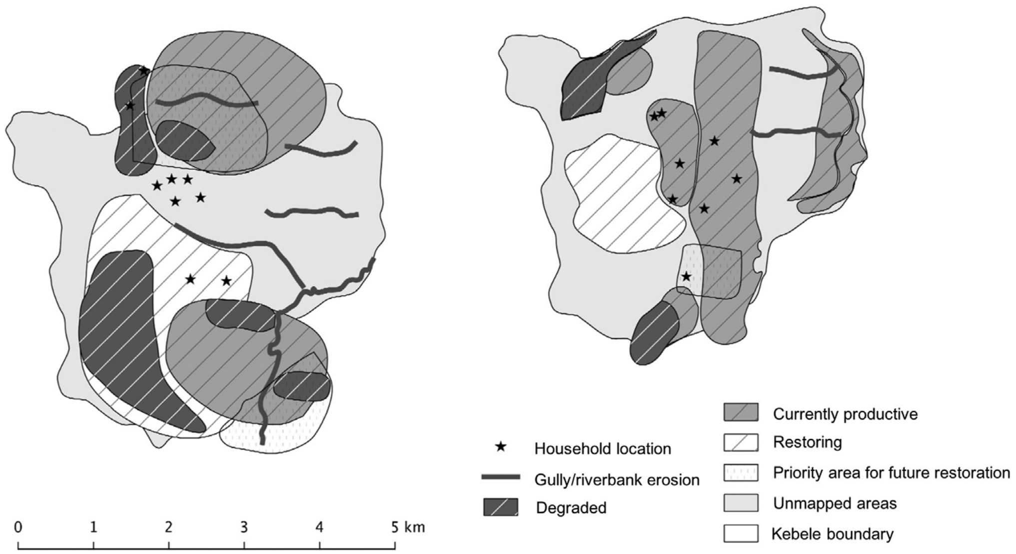

Fig. 4. Digitised versions of the hand drawn maps produced by the women (left) and men's (right) participatory mapping groups held in East Zelsea, showing the spatial variation in how male and female groups perceived degradation.

Table 6
LDN status based on farmers' qualitative assessment of land degradation within their *kebele* ('Area' is calculated from polygons shown in Fig. 3). Farmers' assessments were found to be consistent with the erosion prevalence data derived from satellite image analysis used for site selection (see Fig. 1).

	Lalibela		East Zelsea	
Degradation status	Area (ha)	% of total area	Area (ha)	% of total area
Unmapped area[a]	4319	74	996	62
Restoring (R)	279	5	184	12
Degrading (D)	613	11	45	3
Degraded	589	10	375	23
LDN status (R - D)	−334	−6	+ 139	+ 7

[a] Unmapped areas assumed to be neutral.

and thus possibly LDN. Lalibela, on the other hand, is perceived to be in net degradation and thus may be moving away from LDN.

3.3. Farmers' perceptions of restoration activities

Consistent with the field survey results (Table 3 and 4), farmers interviewed in both sites perceived exclosures and SWC structures as effective in reducing erosion. Other benefits associated with exclosures included fodder production, increased tree cover and the reappearance of streams associated with groundwater recharge. However, with many farmers reliant on communal grazing for their livelihoods, there was often disagreement within communities about their establishment. Farmers stressed the need to reduce livestock numbers prior to further establishment of exclosures and to increase the economic productivity of exclosures through planting productive grasses and high-value fruit or timber trees such as mango (*Mangifera indica*), avocado (*Persea americana*) and grevillea (*Grevillea robusta*).

Perceived benefits associated with SWC structures included reduced soil erosion, enhanced soil fertility, the provision of fodder and fuel, and reduced conflict over the use of *fesses*. Through providing a structural barrier, SWC structures trap sediment and nutrients, helping to reduce soil erosion and improve soil fertility. Perceived challenges with SWC structures included a shortage of labour, steep slopes and shallow, stony soils making construction difficult. In East Zelsea, deep gullies on Vertisol soil types were reported to be difficult to restore without resources such as wire and cement, and that previous check dams had been washed away during heavy rains. Farmers' suggestions for improving SWC options included strengthening community cooperation and increased government support for construction materials.

3.4. Farmers' priorities for restoration activities

Farmers said that the areas they considered the most degraded were their highest priority for restoration. This was because of perceived opportunity costs associated with restricting grazing and agricultural activities on degrading land that still retained some productive potential. Exclosures were established exclusively on severely degraded land with little vegetation cover and stony, shallow soils. Excluding such areas from communal use was perceived to incur a low opportunity cost in terms of grazing forgone but degrading land, with still some productive potential, was perceived as a well-utilised forage source for livestock. This preference for prioritising the most degraded areas for restoration is reflected in the comparison of Fig. 2 and 5, where the majority of areas considered a priority for future restoration efforts are also classed as "degraded", rather than "degrading".

3.5. Variation in farmers' perceptions of restoration

At both sites, farmers highlighted two key factors that influenced acceptability of exclosures: (i) farm size, and (ii) number of livestock. Farmers with many livestock or little or no land relied heavily on communal grazing and were strongly opposed to the establishment of exclosures. In contrast, farmers with sufficient farmland and fewer animals were able to designate an area of land for private grazing. In response to the declining productivity of communal grazing land, some farmers who kept cows primarily for milk production had started using stall-feeding (i.e., feeding crop residues, tree fodder and cut grasses to stall-kept animals). This had resulted in increased animal productivity and they now kept fewer animals. However, due to the labour involved in collecting fodder for large numbers of cattle, they claimed that other farmers, who relied on livestock primarily for preparing cropland and threshing rather than for milk production, did not consider stall-feeding a viable option. It is thought that for these farmers, maintaining a large herd size was a greater priority than increasing animal productivity.

4. Discussion

Our findings demonstrate that engaging land users at the local landscape scale could help improve the implementation and monitoring of LDN through: (i) recognising and understanding variation in perceptions about degradation and restoration options amongst local actors, and between them and other stakeholders, (ii) understanding how rural livelihoods interact with different LDN

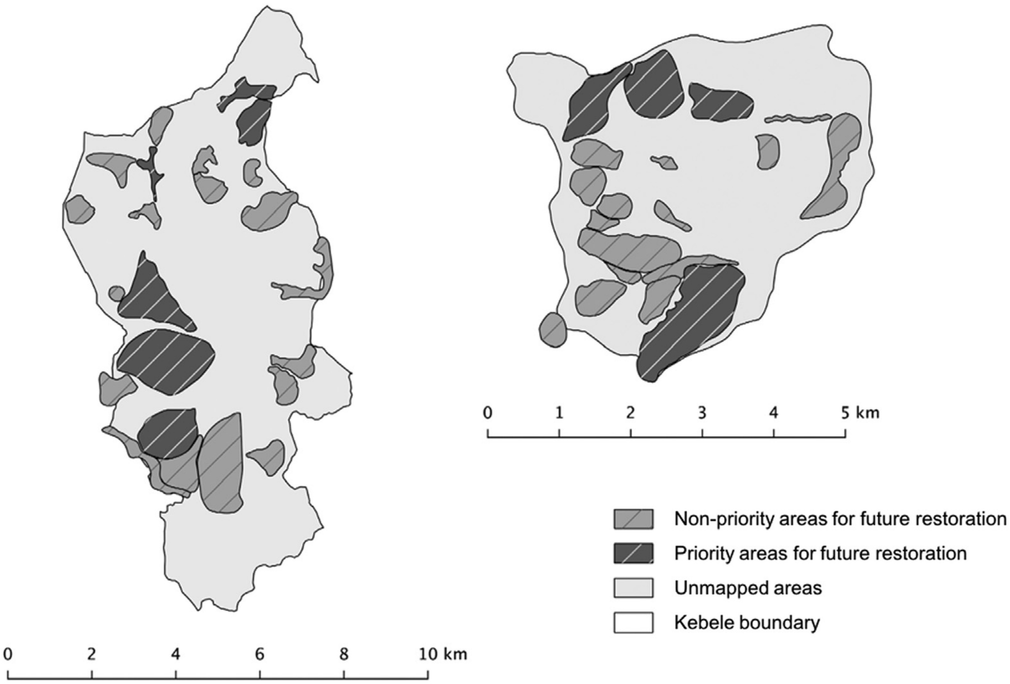

Fig. 5. Priority areas for future restoration as perceived by farmers interviewed in Lalibela (left) and East Zelsea (right).

measures, and (iii) identifying the type, location and causes of degradation at local scales. Here, we discuss the implications of our findings on achieving LDN and propose three integrated guiding strategies for applying LDN at local scales intended to complement the UNCCD LDN framework: (i) negotiate priorities and incentivize action, (ii) match options to context, and (iii) co-produce knowledge and indicators.

4.1. Strategy one: negotiate priorities and incentivize action

This strategy addresses the inconvenient reality that land users may not share the same priorities, in terms of where, when and how to intervene, as one another, or with other actors involved in restoration initiatives (e.g. researchers and current advocates of LDN). Therefore, priorities and options for LDN investments are most likely to be effective where they are negotiated with stakeholders and are coupled with incentive mechanisms sensitive to social differentiation that encourage communities to act now, rather than later.

Our study reveals discontinuity between current scientific perspectives and local values regarding when and where to act. While it is recognised that LDN cannot be achieved by prevention measures alone, research has frequently shown that the prevention of land degradation is more cost-effective than its reversal (Nkonya et al., 2016). A recent study on mapping land restoration potential in Kenya assessed the effort required for restoration by providing a spatially explicit assessment of degradation severity and a compounded index of biophysical parameters (Winowiecki et al., 2018). Such assessments can contribute to identifying critical thresholds of degradation beyond which an ecosystem is unlikely to recover and where a high degree of active restoration is necessary. In recognition of this, the UNCCD LDN framework advocates the avoidance and reduction of degradation over its reversal (Cowie et al., 2018; Orr et al., 2017). However, despite being aware that once severely degraded land may become increasingly difficult to recover, study participants prioritised the areas they considered the most degraded for restoration because of the perceived opportunity costs associated with establishing exclosures on land that still maintained some productive potential, albeit very low. This suggests that land users consider the potential losses in terms of agricultural production as the primary “cost” of land restoration and that simply being aware of impending degradation thresholds might not be enough to influence farmers’ management decisions in order to avoid them.

Our study also revealed that perceptions of degradation and priority areas for restoration efforts varied with gender and that substantial disagreement between farmers existed over the establishment of exclosures on communal grazing lands. Clearly, perceptions of where and how to address land degradation varied amongst local land users.

Such variance in the perception of when, where and how to intervene have direct implications for the implementation of LDN. Willemen et al. (2017) warn that where national level priorities clash with those held by local actors; uptake of LDN actions at local scales may be hindered. While targeting areas identified as important by multiple stakeholder groups could help ensure local buy-in and commitment, target areas and interventions will need to be negotiated amongst actors (i.e., between land users, researchers, extension staff and local government planners, including advocates of LDN). Other incentives may also be required for farmers to engage in LDN measures that aim to avoid or reduce degradation. For example, national, regional and local governments may need to devise mechanisms that reward farmers for the public goods they deliver when managing their land sustainably such as payments for ecosystem services (Börner et al., 2017).

4.2. Strategy two: match options to context

Results from our study show that fine-scale variation in livelihood strategies and resource endowment had resulted in the benefits of restoration being disproportionately distributed among social groups, influencing their willingness to engage in restoration activities. The establishment of exclosures had resulted in resource contraction, in terms of a reduction in the area of available grazing, for those owning many animals or with little or no land. Such land users opposed the establishment of exclosures. While households with greater natural, social and financial resources (e.g., large farms, off-farm income) were better able to cope with such contractions, poorer less resilient households may become increasingly vulnerable to future shocks such as crop failure and drought (Tittonell, 2014).

Benefits are also likely to be differentiated in relation to gender. Exclosures and SWC structures were said to have increased the availability of fuel wood and resulted in the reappearance of streams through groundwater recharge. Given women's role in collecting water and fuel, such impacts may be particularly beneficial for women by reducing the distance and time required for such activities. Men, however, largely responsible for livestock and cash crop production, are likely to benefit primarily from increased agricultural productivity and the use of cut-and-carry livestock feeding options.

To ensure the development of effective and equitable strategies for achieving LDN, it will be crucial to consider who will benefit and who will be disadvantaged by different options and to take measures to give a voice to, and address the needs of, those who may be disadvantaged (Chomba et al., 2017; Easdale, 2016). For example, within our study sites, it may be possible to mitigate disadvantages for some by combining different measures, such as converting to stall feeding and planting improved grasses within exclosures, or entrusting groups of vulnerable land users (e.g., landless farmers) with the management and use of exclosures (Meaza et al., 2016).

Our study also revealed that, although exclosures may increase vegetation cover and fodder for livestock in the long term, they do not necessarily provide the ecosystem services needed to meet immediate livelihood requirements. For example, while farmers considered exclosures effective in increasing vegetation cover, they stressed the need to reduce livestock numbers and to increase the economic productivity of exclosures through planting high-value trees and grasses. Mekuria et al. (2011) report similar findings in their assessment of local attitudes towards exclosures in Northern Ethiopia, where 64% of respondents believed exclosures had negatively affected fuelwood availability, 58% had concerns that exclosures negatively impacted livelihoods through the reduction of grazing land and, while 52% of respondents believed exclosures were "highly" effective at restoring vegetation, 28% ranked their effectiveness as "medium" given the dominance of less desirable species such as acacias. Respondents suggested planting fast growing tree species for fuelwood and construction materials.

To ensure that striving for LDN does not come at the expense of local livelihoods of vulnerable households, as has often occurred where conservation measures involve exclosure (Chomba et al., 2016), LDN efforts should aim to match measures to social context, actively incorporating local perspectives and current livelihood strategies and requirements in their development. Such actions are also likely to increase local participation and commitment to LDN activities.

4.3. Strategy three: co-produce knowledge and indicators

Involving land users in the assessment of degradation can provide insights into local degradation processes and could help increase the local relevance of indicators for monitoring progress towards LDN. Previous studies have shown that Ethiopian farmers hold considerable knowledge regarding degradation processes and that their perceptions of soil erosion generally match empirical findings (Assefa and Hans-Rudolf, 2016; Nigussie et al., 2017; Tefera and Sterk, 2010). Within our study, farmers' qualitative assessment of degradation provides an initial view of whether or not their local landscape is in a state of LDN, as well as spatially explicit information about the location and forms of degradation, which is generally consistent with field survey results. These local assessments cover only a proportion of the land within each *kebele* and provide a snapshot of present perceptions, constraining inferences about rates of change. Nevertheless, they provide useful information for the design and targeting of initial options to arrest and reverse degradation, especially where long-term datasets on land health are absent.

Even where scientific data are available, engaging farmers in the assessment of degradation can help identify local drivers of degradation risk. Study participants identified the use of *fesses* as a primary cause of soil erosion and, as a result, their presence was monitored by the field survey. Although unexplored statistically, erosion was present within the majority of observations taken on cropland with *fesses*, and largely absent from those taken on cropland without. While this does not necessarily imply causation, it highlights how engaging land users in the assessment of degradation can provide insights into locally specific causes of degradation and help improve the design of LDN measures at local scales.

It has also been recognised that complementary indicators to those outlined by the UNCCD LDN framework will be needed to monitor locally specific issues (Orr et al., 2017). Within our study, socio-economic factors, such as labour availability and current household needs, were found to play a part in how productive farmers considered land to be (e.g., farmers considered exclosures effective in increasing vegetation cover but stressed the need to increase their economic productivity through planting high-value trees and grasses). Assessing productivity is unlikely to be a simple question of net primary production, the current metric used by the LDN framework. To ensure LDN efforts consider the amount and type of production that communities require, complementary metrics for measuring productivity at local scales will need to be developed through discussion with land users.

Perhaps because the UNCCD LDN indictors are designed to facilitate reporting at national rather than local scales, they are unlikely to be meaningful to most land users. Soil erosion, however, was an indicator widely used by study participants and is likely associated with reduction in soil organic carbon and other indicators of land health (Winowiecki et al., 2016). Including soil erosion as a core indicator under the UNCCD LDN framework might, therefore, increase its relevance to local land users and coherence in monitoring across scales.

5. Conclusions

Through applying the concept of LDN at the local landscape scale and engaging land users in the assessment of degradation and restoration activities, our study offers a number of key lessons for implementing LDN. Firstly, land users were found not to share the same priorities, in terms of where, when and how to address degradation, as one another, or with other actors involved in restoration initiatives such as researchers and current advocates of LDN. This indicates a need to facilitate negotiation about locally relevant options amongst multiple stakeholders with varying and often competing interests. Secondly, engaging land users provided insights into local degradation processes and spatially explicit information on the location and types of degradation present. Involving land users in the assessment of degradation could improve the design and targeting of LDN measures and help identify locally relevant indicators for monitoring.

Finally, our study revealed that the benefits of restoration were socially differentiated and not everyone may benefit, or do so equally from any specific restoration option. Since one of the main aims for LDN is to reinstate ecosystem functionality for the benefit of people, it is essential to understand how local livelihoods interact with different LDN measures and to ensure that striving for a land degradation neutral world does not come at the expense of the most vulnerable and least resilient community members. Future policy and project development for LDN will, therefore, need to carefully consider the variation in local-level priorities and contextual factors, including social dynamics, gender roles and norms, influencing the acceptability of restoration options and aim to match measures to suit different types of farmers and communities. These lessons can be implemented as three guiding strategies for applying LDN at the local landscape scale: negotiate priorities and incentivize action; match options to context; and co-produce knowledge and indicators.

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Declarations of interest

None.

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